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PACIS 1995 Proceedings

Pacific Asia Conference on Information Systems (PACIS)

December 1995

Organizations' Information Systems Allotment: Balanced Development

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An overall organizational viewpoint of Information Systems (IS) planning that takes account of the increasing importance of the organization and the users of the IS is proposed here. The IS is evaluated according to its weighted ratio of designed resources to needs in the development phase, and then its weighted utilization in the operational phase. Adopting a vertical and a horizontal segmentation permits the use of numerical indices and graphical representation that make it easy to quickly identify insufficient use of resources, bottlenecks and suboptimized resource sharing, from an overall organizational viewpoint. The proposed analytic technique models the complexity existing in distributed computing environments and Information Systems so that cost and utilization can be realistically derived.
This allows a balanced IS development for the entire organization, that will be proportional to its real needs and purposes.

1 Introduction and background

Vast sums and resources are invested in computer system acquisition, in information system (IS) organization, and in improving the efficiency of organizations by means of information technology. It is imperative, therefore, to avoid waste of these resources due to problems of compatibility and effectiveness, efficiency and optimality, as well as the competition among manufacturers. Hence, the questions that inevitably arise are, for example, what is the maximal limiting capability of a particular system, what is its utilization, or performance, or in other words - how does the actual information system fulfill the organization's needs. These questions are fundamental for proper information system design, development and operation.

The development process of the information system usually neglects the issue of considering the organization as a whole, and tend to address specific points that are the main purpose of the IS. Most methodologies for IS development are thus concerned with the way IS answers the problems for which the IS is developed, and overlook the whole organization's needs. This could lead to inefficient use of the IS, or even its failure, if, disregarding the real needs of an organization, an effort is misplaced (Ahituv and Neumann 1990).

Although, in the 1960s, information systems were portrayed in essence as hardware systems, by the 1970s the software component had become equally important and in the 1980s a clear dominance of the software component emerged. In the 1990s, the IS attention is directed towards the users. Only in recent years have researchers begun to examine the information system from the viewpoint of its users, and to try to define user characteristics. IS strategies are more tuned toward those end users' needs and characteristics, and the value of the information system can be estimated as a function of its users. If the system does not meet the users' needs, it will not be used; the extent of IS use is thus indicative of its quality (see for example (Ahituv 1980, Ahituv and Neumann 1990, Doll and Torkzadeh 1988, Neumann and Segev 1979, Rouse 1987).

A distinction of the types of IS users - "internal" and "end-users" must be made, and is justified by most of the researchers (Rockart and Flannery 1983). The *end-users* are those for whom the information system was devised in the first place, and they generally belong to the organization's units that are served by the information system. The *"peopleware"* are users who are part of the information system. These users consume 45% of the IS budget on the average, and thus become a very significant component of the IS. They include the various programmers of applications such as databases, finance systems, DSS, etc., system engineers, DBAs, system programmers, systems analysts, communications programmers, operations' staff, etc. These users constitute part of the information system, and take care of the integral software and hardware systems of the computer, handle their maintenance, their allocation, etc.

The purpose of this paper is to present and apply a study of including users of the information system in its design, development and performance evaluation. The paper employs a technique that IS managers can use in allotting and reallocating IS resources (hardware, software or peopleware) in the correct organizational preferences (Borovits and Giladi 1993). In the next section, the paper reviews the issue of information system evaluation. It then reviews an extension for information system performance evaluation and presents a functional model of an information system in the organizational context. In section 3, this model will be adopted for presenting a phased evaluation for IS design and developing evaluation. After a

discussion of the results, implications for practitioners and researchers are offered in the last section.

2 IS evaluation model

In this section we shall describe briefly the performance evaluation model that was proposed for computer systems (Borovits and Giladi 1993). The model discusses the utilization of the system's components, and then is extended to evaluate the entire IS, and finally the model serves for organizational IS evaluation. This is in accordance with the analytical framework of IS evaluation presented in (Borovits and Giladi 1993), which examines the IS on a vertical segmentation basis: First, the organizational level should be examined, i.e., the influence of the IS on the organization. Then, the Information System itself should be examined - its combined nature and integration. Last, each of the IS components should be examined separately, i.e., the hardware, the software, and the peopleware. We have to be aware though, that we are not dealing with the information itself - and its value to the user (Ahituv 1980). We are concentrating here on the organization of the organizational IS rather then on job effectiveness from the point of view of user utility.

Utilization, used in the operational IS evaluation phase, is interchangeable with allotment, used in the design evaluation phase. Thus, even though the model discuss utilization as the parameter of interest, it should be interpreted and used for allotment in the design phase.

2.1 Basic evaluation model

Borovits and Ein-Dor developed a cost/utilization model for evaluating computer system efficiency (Borovits and Ein-Dor 1977), in terms of cost and component utilization. This model makes use of two indices - a utilization index and a balance index. The utilization index is a weighted average of the utilization of each hardware component by cost ($F = \sum_i P_i U_i$, where P_i is the cost of the i^{th} hardware component, and U_i is the use/utilization of this hardware component).

The balance index measures the weighted variance of the hardware components usage by their cost ($B = 2\sqrt{\sum_i (F - U_i)^2 P_i}$, where F is the utilization index, and P_i and U_i are as defined previously for the utilization index). According to the model, as F increases (it ranges from 0 to 100%), system utilization is greater and more efficient. Similarly, as B decreases (it ranges from 0 to 1), the system becomes more balanced.

An advantage of this model is the manner in which it may be represented graphically.

It is possible to represent the utilization of each item (use divided by capacity), along the relative cost "axis", in order to visually weight the hardware component utilization, as will be demonstrated in the case study described below.

In this way, these models can portray performance, i.e., actual use versus planned use (or capacity), measured for each system component (hardware or software) separately. In the graphic representation this is the *y-axis*. It can also be used for allotment, i.e., IS resource allotment versus IS needs. However, in weighting the components (the *x-axis* in the graphic representation) a problem arises. Weighting of components must be according to their importance, their usefulness, their worth, or their value to the organization. But these characteristics are difficult to measure since they are not objective. It is difficult to compare the CPU value, for example, to the value of the DBMS component in the software, or to the programmer's value, or even to the disk value. The cost/utilization model weights the hardware components according to their relative costs (which is the *actual share* of the component in the system). Among other possibilities, weighting may be carried out in accordance with the value of their output (which is the *valued share* of the component in the system).

2.2 Extended IS evaluation model

A "uniform" model was proposed (Borovits and Giladi 1993) which measures use or output divided by capacity or planned use for each component, weighted by its actual share, that is, by its relative cost. We shall modify it slightly, and use it for IS resource *allotment* divided by IS resource needs, weighted by its planned share (see next section for details). The model includes the hardware components, the software components of the correlated cost model, and the peopleware components according to their cost. For a component whose capacity is known, as for example storage volume of disks, or CPU operation time, the allotment is simply the ratio of designed capacity to the planned use, and the utilization is simply the ratio of use to capacity. In the case of software or peopleware, the same algorithm is used; objectives are determined for each component, according to the purpose for which it should be acquired or rented - for example, quantity of transactions, number of queries or reports, volume of communications traffic, or quantity of projects or work hours, and the allotment is the ratio of the planned acquisitions to the design needs of that component. The utilization is then the ratio of the output of the components acquired or rented to the planned value for which they were attained. For the purpose of evaluating the information system containing hardware, software, and peopleware, the utilization and balance indices will be used separately, for each of the three (hardware, software and peopleware); the utilization/allotment index is $F_j = \sum_i P_i U_i$, where j is 1, 2 and 3, for the hardware, software, and peopleware, respectively. P_i is the cost of the i^{th} hardware, software, or peopleware component, depending on which F_j is being calculated, and U_i is the use/utilization of that component

(for hardware - use/capacity, for software and peopleware - output/planned value or output/objective). In the case of computing allotment, U_i is the IS resource allotment/IS resource needs. The weighted average of F (the sum of the F_j products of the hardware, software, and peopleware and the relative cost of each of the three factors) is calculated, in order to compute the utilization/allotment index of the information system as a whole.

The balance index measures the weighted variance of the utilization/allotment of the hardware, software, and peopleware components according to their costs: $B_j = 2\sqrt{\sum_i (F_j - U_i)^2 P_i}$ where j is 1, 2 and 3, for hardware, software, and peopleware, respectively, F_j is the respective utilization/allotment index, and P_i and U_i are as defined previously for the utilization/allotment index. In order to compute the balance index of the information system, a further calculation of the balance factor between the hardware, software, and peopleware, is made: $B_4 = 2\sqrt{\sum_j (F - F_j)^2 P_j}$ where P_j is the cost portion of the hardware, software, or peopleware in the cost of the information system as a whole. B, the balance factor of the information system, is obtained from the average of B_1 through B_4, in order to express not just the imbalances of hardware, software or peopleware, but also to express the imbalance between the hardware and the software (even if, for example, both the hardware and the software themselves are balanced). In accordance with the model, as F increase (F now can be greater than 100%, if the software or the peopleware components take more than their planned usage, or allotment of IS resources is more than needed, as is usually the case), so does system allotment, utilization or efficiency, as the case may be. Likewise, as B decreases the system balance increases.

2.3 Evaluating IS at the organizational level

So far we have described models dealing with evaluation of the two bottom levels - that of the computer system, and that of the information system as a whole. In none of these models was the effect of the user on computer or information system performance considered, although it is clear that users have a most decided effect on information system performance - even when we ignore completely the value of the information. The level of expertise of an end user (in terms of professionalism, education, etc.) will very much determine the performance of the various IS components (such as software tools designated for development, etc.), while the type of the end-user (in terms of development, decision-making, traffic recording) will affect program performance (i.e., TPS as compared to DSS program types).

Other important end-user characteristics include user motivation (satisfaction from using the information system, level of complaints, persistence time, session length), profit accruing to the user from use of the information system, and more.

Borovits and Giladi's model (Borovits and Giladi 1993) enables evaluation of performance at the organizational level, which avoids the problems in attempting to identify the organization's (and its users) effects and influence on the IS, and of establishing the organization's (and users) relevant characteristics.

The model includes a third dimension, in addition to the two dimensions discussed above - relative cost to the organization of an IS component (the *x-axis*), and allotment/utilization of the component (the *y-axis*). This third added dimension is that of the organization's departments, divisions, or functions (*z-axis*). In the same way that the IS resources were represented as weighted by their value, the organization functions are represented as weighted by their importance, in terms of factors such as their relative annual budget, relative profitability, or relative output.

The implicit assumption here is that each organizational function has a particular and usually homogeneous type of user, thus obviating the need to identify users, quantify them, or examine the effects of user characteristics themselves. In this case, instead of discussing allotment/utilization of the resource for the entire organization (*y-axis*), allotment/utilization of the resource in the particular function of the organization is discussed. Graphically the model appears as depicted in figure 1.

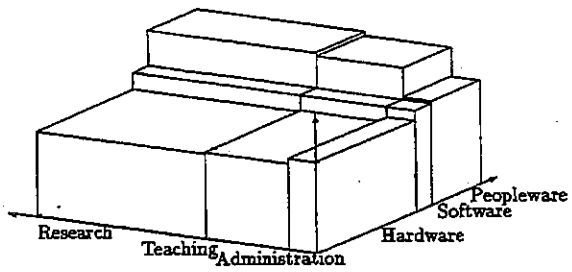

Figure 1: Organization's IS Cost/Utilization

Each block in figure 1 represents the use of information system resource by the function in the organization. It can be viewed also as the allotment of IS resource, by the function in the organization. The greater the area of the block, the greater the importance of the allotment/utilization of this resource for/by this organizational function. Utilization and balance indices can now be defined for each organizational function separately, by using the weighted products of the allotment/utilization and the relative cost of the resource, belonging to the organizational function. In this manner, it is possible to identify organizational functions that are wasteful, and those that have bottlenecks, and to better allot resources within the organization, during the development phase, or later on, during the IS operation. In addition, organization-

wide utilization and balance indices can be defined, by weighting the allotment/utilization by the relative cost of the IS resource and by the relative share of the function in the organization: $F = \sum_i \sum_j P_i S_j U_{ij}$ where P_i is the cost of i^{th} information system resource (hardware, software, or peopleware), S_j is the importance of the organizational function within the entire organization (for example, its relative budget, relative output, or relative profitability), and U_{ij} is the allotment or use/utilization of the i^{th} resource by the j^{th} organizational function utilizing it.

The balance index measures the weighted variance of allotment/utilization of resources according to their cost and in accordance with the importance of the organizational function utilizing them: $B = 2\sqrt{\sum_i \sum_j (F - U_{ij})^2 P_i S_j}$ where F, P_i, S_j, and U_{ij} are defined as above.

3 Evaluation of IS design & operation

The central issue in developing IS should be the evaluation of the design, its quality, and then its operation, by the same tools. These tools should allow quantification of the evaluations, and comparison between them. The ability to check different design alternatives, from an organizational viewpoint, should be feasible, using these tools.

An important aspect of IS design and development is its expected performance, mainly utilization, as it expresses the organizational usage of it, and it thus implies the success or failure of the IS. We shall use the evaluation methodology based on the cost/utilization model (Borovits and Ein-Dor 1977), extended for user inclusion (Borovits and Giladi 1993), and modified in this study for measuring IS resource allotment in a similar and common way, as presented in the previous section. Other evaluations of the information systems can be done, based on qualitative and quantitative measures. Three types of quantitative performance indices (utilization, productivity, and responsiveness) exist, which are mutually correlated by performance models (Ferrari 1978, Jain 1991). The usage of the information system as a whole reflects the qualitative measures (such as reliability, user friendliness, etc.), and the productivity and responsiveness of the quantitative indices of the IS.

3.1 Phased evaluation

We should evaluate two phases in the IS life-cycle; the first is its design, and the second is its operation. In the operational phase, utilization of the IS is simply the ratio of the IS usage to the IS capacity (or planned resource allotment). As for the design phase, the ratio of the IS resource allotment to the defined IS needs can serve equally well for a design measure. This ratio will be referred to as *"allotment"*, analogous to the *"utilization"* used in the operational phase.

Utilization of computer systems can be easily evaluated, simply by measuring their various components, by means of software tools or designated hardware tools. These evaluation principles can be conveniently used for displaying utilization of each of the three levels related to evaluation of information technology (the organization, the information system, and the computer itself) and, as demonstrated in the previous section, they can include the effects of information system components under discussion, i.e., hardware, software, peopleware and end-users.

The related measure of "utility" for the design phase can simultaneously be used to display all the IS components, of each of the three levels of evaluation.

3.2 Methodology

We propose a scheme that allows IS managers to determine the balanced design and performance of IS components cross organization, and assess the relative importance of IS projects and efforts (figure 2). This helps the IS managers in allotting and reallocating IS resources (hardware, software or peopleware) in the correct organization preferences, during the development phase, and during the operational phase later on. It further allows the IS manager to compare between the allotment and the utilization of the IS resources, and to correct the design of the IS according to the real needs of the organization.

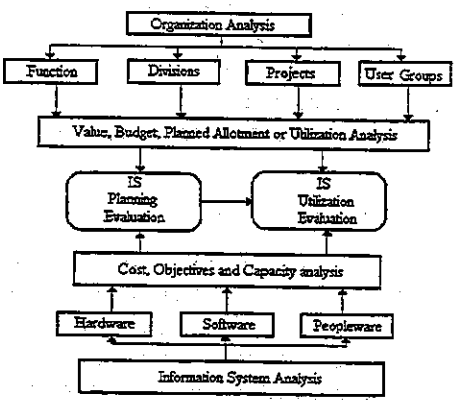

Figure 2: Organization's IS Balanced evaluation methodology

If the organization's needs, defined during the design phase, are correctly determined, and match those of the organization's usage, then, $F_{utilization} = 1 / F_{allotment}$. Any deviation from this equation suggests that either the determination of the needs was incorrect, or the usage of the IS resources is influenced by a bad IS ($F_{utilization} < 1 / F_{allotment}$), or good IS ($F_{utilization} > 1 / F_{allotment}$). Thus, comparing $F_{utilization}$ to $1/F_{allotment}$ might suggest the success or failure of the IS.

4 A case study

A case study of a university's IS is demonstrated here, so that the indices usage and their graphical representations can be made clear.

The university is quite small, with 8500 students, 25% of whom are graduate students. There are about 500 academic faculty members and 300 administrative personnel.

The university's IS is based on distributed computing and during the last few years an extreme turn over has taken place - from a powerful centralized mainframe into spread scientific and engineering workstations and personal computers with a high capacity wideband communication network.

The remaining main computers of the university (IBM 4381 & DEC 6430) serve mainly the university administration, and are worth K$420. The library's computer (DEC 4300) is worth K$100, and is used mainly by researchers (90%) and students. The Unix workstations and servers are worth about K$800, and are used by researchers (65%), students (30%) and the administration (5%). The personal computers (IBM compatible and Macintosh) and their attached equipment (printers etc.) are worth about K$1000, and are used by researchers (70%), students (20%) and the administration (10%). The communications equipment (routers, cabling, interfaces, connectors, etc.) is worth roughly K$600, and is used in proportion similar to those of the personal computers. The software can be divided into two main groups - the administrative component and many research and teaching software packages, along with office and word processing software in the other group, aimed at researchers and students. The investments in software have so far reached about K$600, evenly divided by the two software groups. As for personnel, there are 37 employees serving the IS (more than 12% of all the university's administrative staff). 11% of this personnel are operators, 20% are MIS programmers, 35% are servers and PC's programmers, 11% are communications engineers, 16% are consultants and the rest are in general managing.

The utilization of the IS resources outlined above are summarized in table 1.

The hardware elements' utilization is shown in figure 3. Calculating the F_{hardware} will indicate a utilization index of 67.1% and a balance index of 0.46. Those measures indicate average Cost/Utilization of 67%, and an unbalanced system, i.e. irregular use of the system's hardware in the sense that a significant component is underutilized.

Category	IS Resource	Value	Usage			Utilization
			Administration	Students	Researchers	
Hardware	MIS IBM 4381	K$300	100%	0%	0%	90%
	Financial DEC 6430	K$120	100%	0%	0%	40%
	Library DEC 4300	K$100	0%	10%	90%	100%
	Unix Servers & WS	K$800	5%	30%	65%	80%
	Personal Computers	K$100	10%	20%	70%	40%
	Communications Equip.	K$600	10%	20%	70%	90%
Software	MIS	K$300	100%	0%	0%	80%
	Research & teaching tools	K$300	0%	30%	70%	80%
Peopleware	Management	K$100	20%	30%	50%	100%
	Operations	K$160	30%	20%	50%	120%
	MIS Programmers	K$290	100%	0%	0%	70%
	PC & Unix programmers	K$160	5%	20%	75%	120%
	Communications engineers	K$160	10%	25%	65%	100%
	Consulting	K$230	0%	30%	70%	80%

Table 1: IS resources utilization

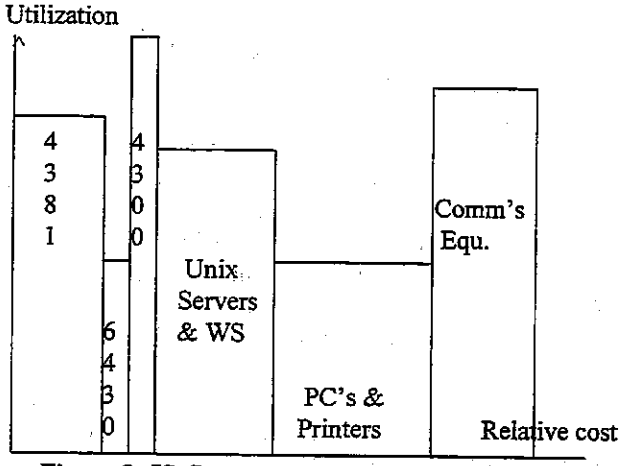

Figure 3: IS Components' Cost/Utilization

The same analysis can be done on the peopleware component, yielding the results depicted in figure 4. The $F_{peopleware}$ calculated indicates a 100% utilized personnel, and a 0.41 balance index, indicating a quite unbalanced allocation of IS staff.

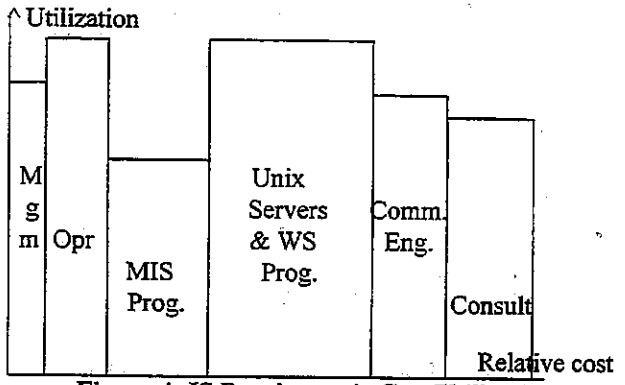

Figure 4: IS Peopleware's Cost/Utilization

It is now possible to delineate a graphical representation for the complete IS level of the university (figure 5). The calculated Cost/Utilization ($F_{utilization}$) is 78.2%, and the balance index is 0.29, implying a need for reallocation of IS resources.

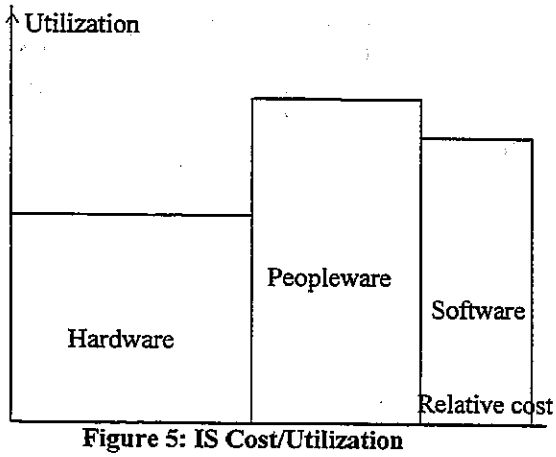

Figure 5: IS Cost/Utilization

When considering the functional assignment of IS resources, we address the budgeting of each of the functions - research, administration, and teaching. If, for example, 10% of the 2000 communications ports are devoted to administration, 20% are dedicated to teaching (classrooms and students' laboratories) and the rest goes to the researchers, and this ratio remains about the same for every other resource allocation, then we can conclude that this is the relative "importance" of those functions. Calculating now all the utilizations for each function, we can picture the functional organization IS utilization as depicted in figure 1.

Allocation of IS resources for the coming year was carried out using this model. The budget was cut into current budget (maintaining the existing IS) and development budget (adding IS resources and improving IS services). The total budget was K$3650, of which K$1440 was designated for the peopleware budget, K$310 was the software budget (2/3 from it was development budget), and the rest was allocated to hardware: K$650 for Unix servers and WS (2/3 for development budget), K$600 for personal computers and printers (2/3 for development budget), and K$650 for communications (half for maintenance, of which ¼ is for telecommunications usage fees).

The intended $F_{allotment}$ was 130% (in the development budget), in order to ease the rising pressure in the distributed equipment and channels, and decreasing the balance index further to 0.15.

5 Discussion and conclusions

We used the model in the case study first to analyze the utilization index of current operations, and then to check the designed allocation planning. The proposed scheme allows the IS managers to determine the balanced usage and design and performance of IS components cross organization, and to assess the relative importance of IS projects and efforts. It is shown how easily it was used by the university staff to assess their planning and resource allocation.

The computed indices award the IS manager some insight into the usage of the IS in the organization. Using the indices might well reflect the overall utilization of the IS resources in the organization, indicating the need to extend the IS resources (as F care for 100%), or the need to educate the organization's users to take advantage of the IS resources (when F diminishes). It might also imply irregularity (hyper or hypo utilization) in using substantial IS resources by principal functions of the organization (as B tends to 1).

In the case of a hyper utilized IS resource, the IS manager should add or allot such a resource, so that its total utilization (actual vs. planned output or capacity) drops to the organization average utilization. In an organization, this might be as simple as reallocating those resources, taking them from the hypo utilizing function, and balancing the organization.

The dynamic usage of those indices illuminates trends in the organization's IS, denoting processes that the IS manager should be aware of.

The proposed model enables evaluation of an information system from an organization-wide perspective, and provides tools for comparing different organizational functions both in the planning phase and then in the implementation and operation phases. The model enables precise identification of bottlenecks or waste in the organization, giving expression to their economic implications on the one hand, and the importance of rectifying them on the other.

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